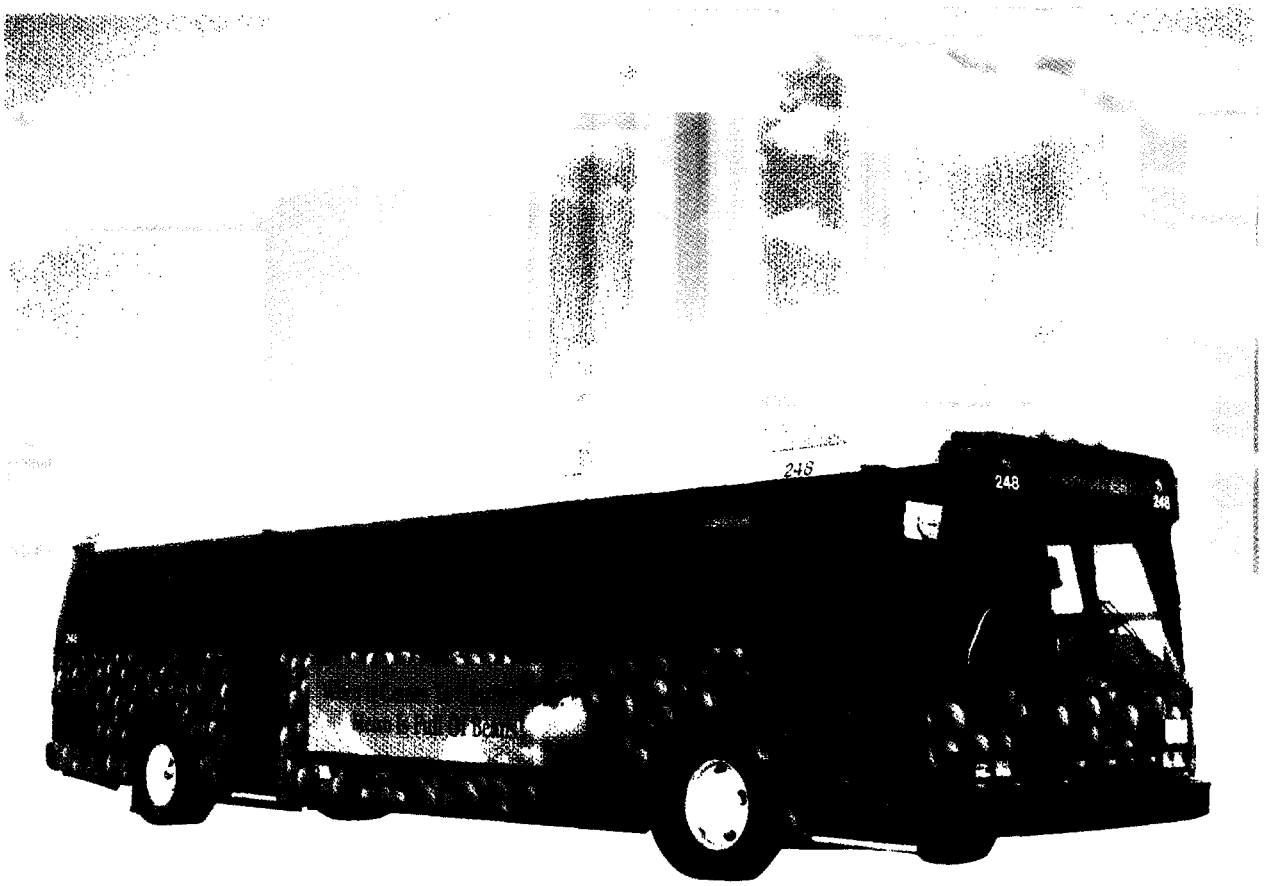

THE BIODIESEL INDUSTRY IN THE UNITED STATES

An Industry On the Move

AN UPDATE

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Three years ago, biodiesel was almost unheard of in the United States ...

but look at us now!

Biodiesel's environmental and energy security benefits are widely recognized, and this renewable transportation fuel is poised to contribute to alternative fuel programs all across the country. World-wide biodiesel production is increasing geometrically, and efforts are under way to construct the first world-class, dedicated biodiesel plant in the United States.

Photo courtesy Deborah Boldt, City of Chicago.

Secretary of Energy Hazel O'Leary, Chicago Mayor Richard Daley, and Illinois Governor Jim Edgar at the Chicago Clean Cities kick-off.

It's been a long journey, involving thousands of hours of testing and millions of miles of demonstrations, but biodiesel has rapidly made its presence known in the alternative and clean fuels markets.

How did we get here? And where are we going?

What is Biodiesel?

Biodiesel is the name for mono alkyl esters derived from renewable biological sources. It can be used in compression-ignition (diesel) engines with essentially no engine modifications. Pure biodiesel is biodegradable, nontoxic, and essentially free of sulfur and aromatics. Bio-based diesel fuel is not a new idea—Rudolf Diesel, inventor of the diesel engine, originally designed the engine to run on pure peanut oil. Biodiesel is made from vegetable oils, animal fats, and used oils and fats, which are reacted with alcohols in the presence of a chemical catalyst such as sodium hydroxide. It has been in use in Europe and other countries for years. In the U.S., biodiesel is just emerging, but is developing rapidly into a viable addition to the fuel market.

The nationwide effort started in 1992 with the National Soy Fuels Advisory Committee, which became the National SoyDiesel Development Board and is now known as the National Biodiesel Board (NBB). Funded with soybean farmer checkoff dollars provided by the United Soybean Board (USB) and Qualified State Soybean Boards (QSSBs), the NBB is the leader in working with government and business to set the foundation for the biodiesel industry. The American Biofuels Association (ABA) and other organizations have also worked to assist these efforts.

Photo courtesy of the U.S. Department of Energy

The biodiesel industry is working cooperatively with government departments and agencies to meet all regulatory requirements. More than $10 million has been spent by soybean farmers over the past three years to carry out biodiesel research, demonstrations, government compliance, and industry information programs.

The farmer-directed NBB has established a policy of openness and inclusivity and a dedication to meeting the environmental, energy security, and economic objectives of the nation.

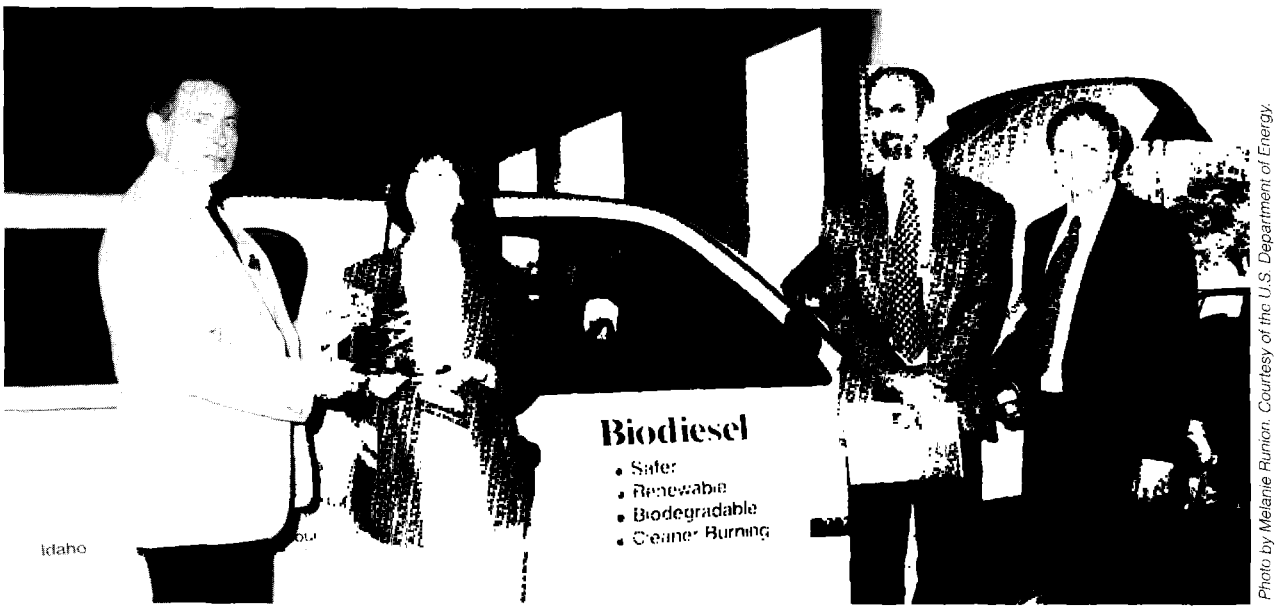


Photo by Melanie Runion. Courtesy of the U.S. Department of Energy.

DOE Assistant Secretary for Renewable Energy and Energy Efficiency Christine Ervin and Dr. Charles Peterson of the University of Idaho at Moscow (left) show off the DOE "Best of Category" Award given to the Idaho Department of Water Resources for work done by Dr. Peterson. Richard Moorer, Associate Deputy Assistant Secretary (center right), also inspected the biodiesel-powered vehicle and was briefed by Engineering Technician Daryl Reece (right).

The U.S. Department of Energy (DOE) and the Department of Agriculture (USDA) have taken the lead among government agencies in providing funding and technical support for commercializing biodiesel, as have the National Renewable Energy Laboratory (NREL) and other DOE and USDA laboratories.

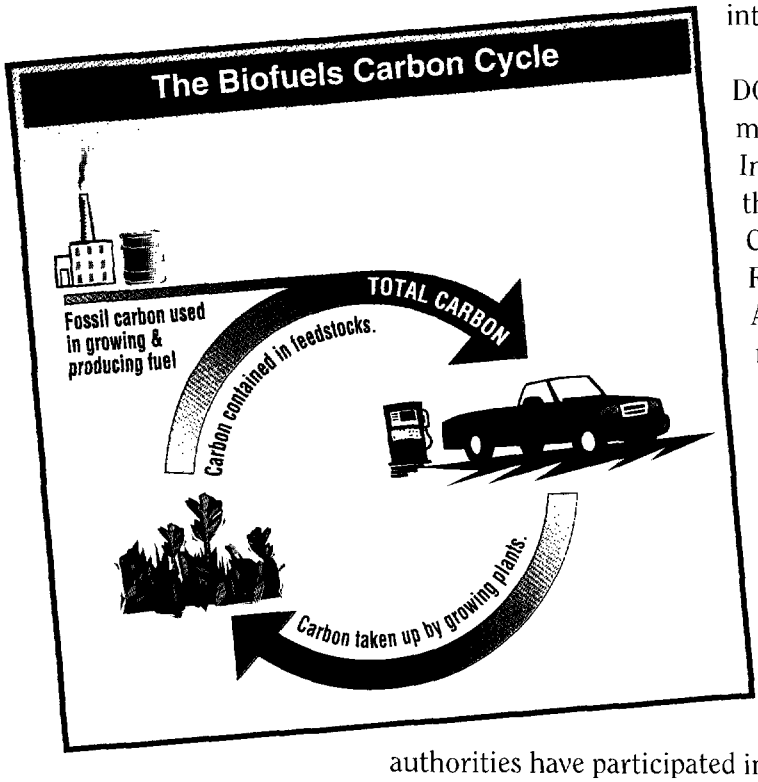
NREL's Alternative Fuels Data Center (AFDC) is collecting data from a comprehensive, controlled test which compares buses running on biodiesel, ethanol, natural gas, methanol, and petroleum diesel. Biodiesel and regular diesel buses have been tested by the Bi-State Development Agency (the St. Louis regional mass transit authority). The project was jointly funded by DOE and NBB. NREL is also cataloging data from NBB biodiesel demonstration programs around the country for inclusion in a comprehensive, publicly accessible database.

Courtesy of NREL, Golden, CO

The National Renewable Energy Laboratory Alternative Fuels Data Center is a clearinghouse for biodiesel demonstration data.

Recognition of Biodiesel

Chicago and other cities are including biodiesel in their Clean Cities plans. This DOE program is a major part of the nation's energy policy. This voluntary program encourages communities to use alternative fuels by integrating complementary programs.



DOE also has lead responsibility in implementing the Climate Change Action Plan. In accordance with the terms set forth in the Framework Convention on Climate Change at the 1992 Earth Summit in Rio de Janeiro, Brazil, the Clinton Administration committed the U.S. to reducing greenhouse gas emissions to 1990 levels by 2000. Biodiesel is a superior transportation fuel that can contribute to meeting this goal, because of its very positive energy balance and because it is part of the natural carbon cycle.

Three years ago, 98% of mass transit operators had never heard of biodiesel. Now, more than 80 mass transit authorities have participated in NBB-funded demonstrations. These demonstrations have generated positive recognition for biodiesel nationwide.

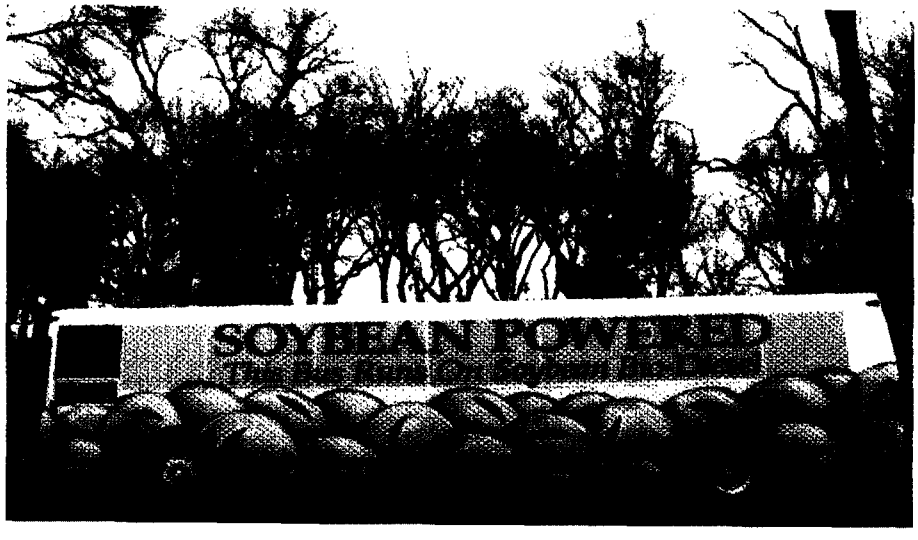
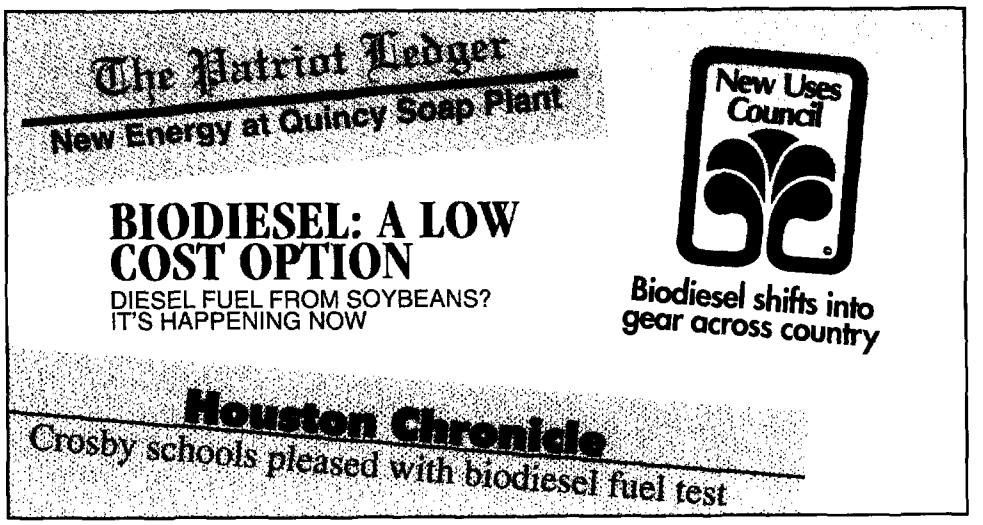


Photo courtesy of Nebraska Soybean Board.

Consequently, biodiesel has captured the attention of the public and been the subject of stories in a variety of publications and professional journals.

"Bean buses," such as this example in Lincoln, NE, have greatly increased the public's recognition of biodiesel.



More comprehensive reports detailing its environmental and economic benefits have also been published. For example, the Congressional Research Service, the research arm of the Library of Congress, issued a 1993 report entitled *Biodiesel Fuel: What Is It? And Can It Compete?* (CRS # 93-1027).

In addition, NBB publishes the *Biodiesel Report*, a monthly newsletter highlighting research developments and regulatory and marketing issues of the biodiesel industry. It is distributed to policy and decision makers across the U.S., and includes subscribers in a dozen countries.

In order to respond to the public's interest in biodiesel, the NBB works closely with the DOE's Alternative Fuels Hotline. The Hotline provides information on all alternative fuels to the public through a nationwide toll-free telephone number (1-800-423-1363).

NBB has also established its own market information line with an "800" telephone number to answer the questions of fleet operators about biodiesel. These hotlines provide extensive support to more than 1,000 callers each year.

Further, the NBB has generated a database of more than 200 technical articles on biodiesel which it has cataloged and indexed. This index is available as part of NBB's 1995 update of the publication *Biodiesel: A Technology, Performance and Regulatory Overview*.

In 1994, the market research firm Booz-Allen & Hamilton, Inc., completed a comparative study of biodiesel and other alternative fuels in the urban bus market. This analysis concluded that biodiesel is cost-competitive with other alternative fuels on a full fuel-cycle basis.

The Research Effort

Behind the biodiesel publicity effort is an extensive, ongoing, cooperative program of engine testing being conducted at several EPA-recognized emissions laboratories. The results of this research have been consistently positive. Research to date has focused primarily on determining optimum blend levels and on maximizing emission reductions to meet the requirements of the Clean Air Act and federal regulations.

Government and industry support for biodiesel research and testing has increased steadily over the past several years, reinforcing the farmer-supported effort.

Funding Support of Biofuels/Biodiesel Programs (in thousands)*

	FY92	FY93	FY94	FY95 (projected)
DOE	$530	$500	$1,096	$1,550
USDA	N/A	$961	$1,372	$1,500
AARC**	0	$176	$400	‡
RBEP***	N/A	$150	$300	$500
DOD	0	$475	$130	$500
Industry	0	$100	$500	$5,000

** These are best estimates based on available information provided by a variety of sources. The important consideration is the significant increase since the biodiesel industry was launched. ** AARC — Alternative Agricultural Research & Commercialization Center. *** RBEP — Regional Biomass Energy Program, a program of the Department of Energy.*
‡ To be determined.

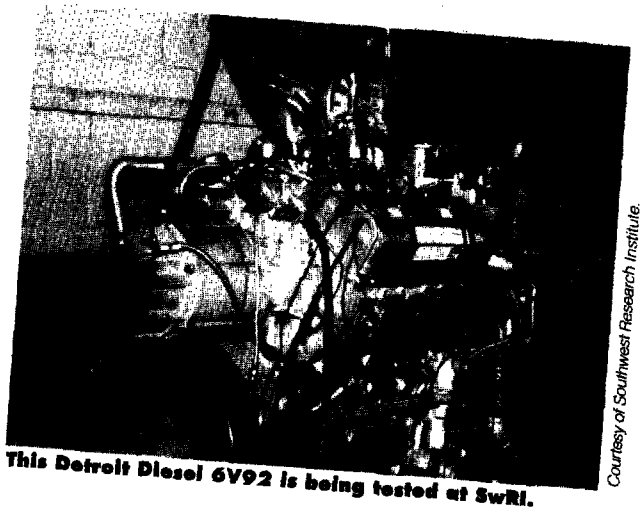
At the Southwest Research Institute (SwRI) in San Antonio, TX, testing jointly funded by NBB and the Alternative Agricultural Research and Commercialization (AARC) Center shows that a 20 vol% blend of biodiesel reduces emissions of carbon monoxide (CO), particulate matter (PM), and unburned hydrocarbons (UHC). SwRI recorded a slight increase in NOx (oxides of nitrogen), and verified other tests showing a similar NOx increase as well as anticipated decreases in PM, CO, and UHC. On average, tests show a 10% reduction in PM for biodiesel at a 20% blend level.

Testing has also been conducted at the ORTECH labs in Ontario, Canada. This research, designed to show that biodiesel meets EPA emission requirements, tested several alternative methods of reducing NOx emissions. As is clearly demonstrated in the table (next page), NOx can be decreased with an injector timing change. Using an oxidation catalyst, PM, CO, and UHC can be reduced even further. With these modifications, regulated emissions (PM, CO, and UHC) can be reduced by more than 40% with an accompanying NOx decrease.

Emissions Reductions with a 20% Biodiesel Blend				
Emissions Reduction Method: Engine Configuration	**PM g/bhp-hr***	**CO g/bhp-hr**	**THC g/bhp-hr**	**NOx g/bhp-hr**
Baseline: No. 2 diesel, no engine modifications	0.261	1.67	0.45	4.46
20% biodiesel with 3° retardation in injector pump timing	0.216 (-17.2%)	1.50 (-9.8%)	0.38 (-14.2%)	4.25 (-4.6%)
20% biodiesel with timing change and catalytic convertor	0.191 (-26.8%)	0.45 (-72.8%)	0.12 (-73.2%)	4.32 (-3.1%)

*grams/brake horsepower-hour
Source: ORTECH

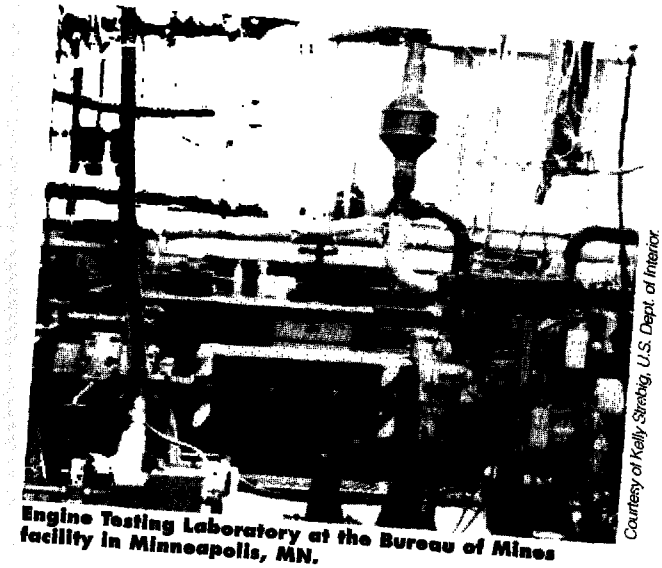
In addition to research on "worst case" and "representative" engines that has been conducted to meet provisions of the Clean Air Act and EPA regulations, a major test project includes cooperative research with the U.S. Bureau of Mines (Department of Interior). Here biodiesel is proving to be a superior fuel in reducing emissions in underground operations.



Courtesy of Southwest Research Institute.

This Detroit Diesel 6V92 is being tested at SwRI.

The primary test sites used by NBB include SwRI; ORTECH; the National Institute for Petroleum and Energy Research (NIPER) in Bartlesville, OK; and the High Altitude Test Center at the Colorado School of Mines in Denver. Other sites include West Virginia University, Morgantown; Engineering Test Services, Charleston, SC; and Environment Canada, Ottawa, Ontario.



Courtesy of Kelly Strebig, U.S. Dept. of Interior.

Engine Testing Laboratory at the Bureau of Mines facility in Minneapolis, MN.

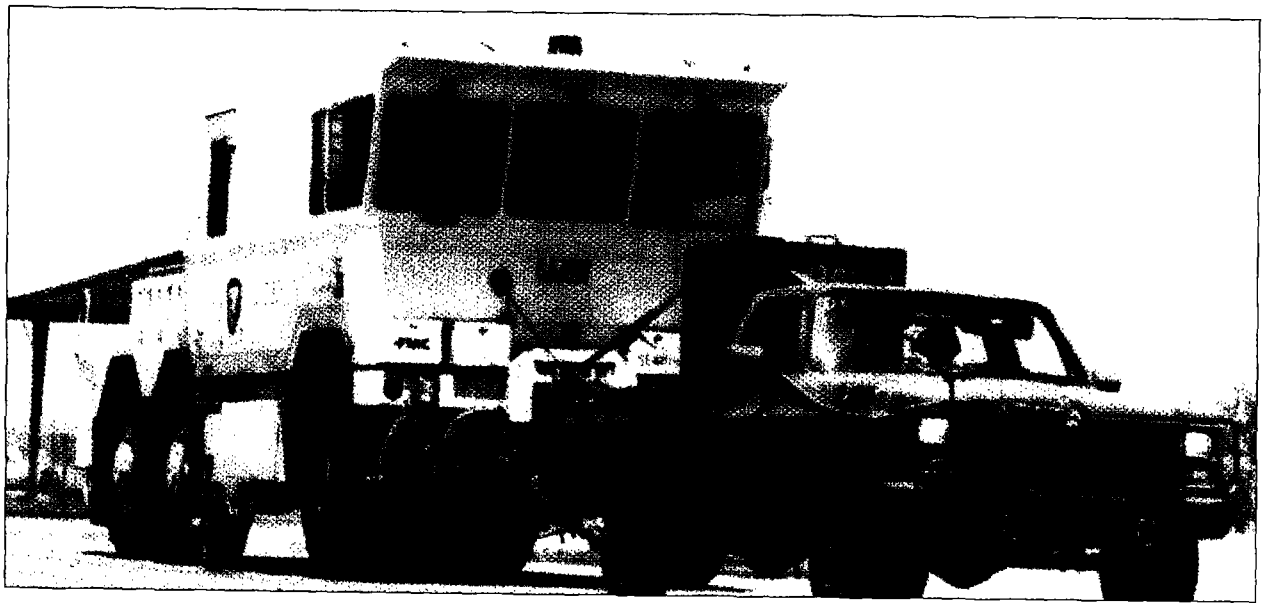


Photo by William Isbell. Courtesy Jerry McCauley

Testing engine performance using a mobile dynamometer at Yuma, AZ.

An extensive testing program is being conducted in cooperation with the Department of Defense at the Army's Yuma Proving Grounds. This test is being managed by the Systems Engineering Directorate of TARDEC (Tank Arsenal Research & Development Engineering Command) to determine whether biodiesel could be used as a military fuel to help meet tough new diesel exhaust emissions standards. According to early results, the B20 blend (20 vol% biodiesel/80 vol% JP-8) outperforms neat JP-8, the U.S. Army's "one fuel for the battlefield."

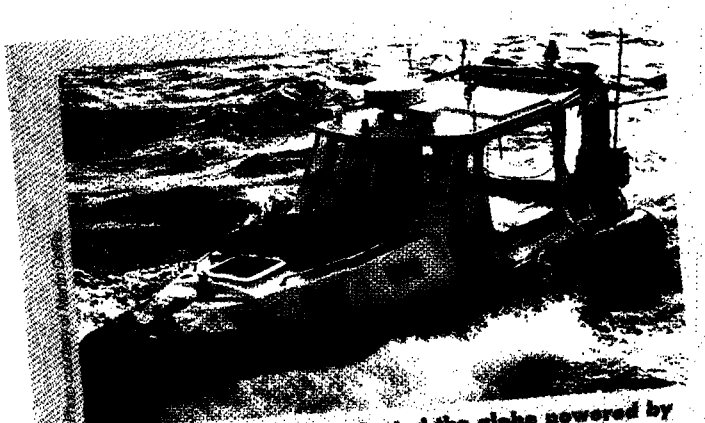


Photo courtesy of the Discovery Channel

The SUNRIDER circumnavigated the globe powered by biodiesel.

Photo courtesy of the Discovery Channel

Use of biodiesel in environmentally sensitive areas, such as the Chesapeake Bay, can contribute to keeping wetlands and marine environments pristine.

Demonstrations have been conducted in 34 states by universities, government agencies, private industry, and mass transit authorities. The fuel has been used in small and large trucks, snowplows, and buses. It has also been used in off-road applications including boats, combines, tractors, generators, and construction equipment.

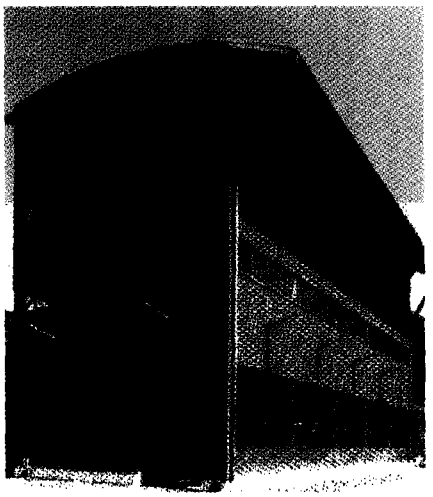
Additional marine demonstrations are under way in San Francisco, the Great Lakes, and the Chesapeake Bay. Because neat biodiesel is biodegradable and nontoxic, it is an excellent fuel for environmentally sensitive areas, such as marshes and waterways.

The International Scene

Biodiesel is already being used commercially worldwide. Many European countries are rapidly developing biodiesel programs to alleviate surplus oilseed production on the world market, provide rural economic development, improve the environment, and reduce dependence on foreign petroleum.

The European experience with biodiesel has been a positive example for the United States. Much of the early data originated in Europe, and the widespread acceptance of biodiesel by engine and vehicle manufacturers, fuel users, and governments has shown that it is possible to commercialize the fuel. Given the support received by the U.S. biodiesel industry from its European counterparts, it is appropriate that European and Canadian researchers are becoming active participants with the U.S. on joint projects.

Currently, France has the largest biodiesel production capacity in the world and is using biodiesel in 5 vol% blends with petroleum diesel. Austria, Germany, and Italy have pioneered uses of 100% biodiesel in transportation and equipment operated in environmentally sensitive areas. Other European nations such as the Czech Republic, Slovakia, Hungary, Sweden, Denmark, Belgium, and the United Kingdom are aggressively moving forward with biodiesel programs of their own.



Vogel and Noot Biodiesel Plant in Bruck, near Vienna, Austria.

Photos courtesy of Vogel & Noot.

Regulatory Issues

Several federal agencies are key to the continued success of biodiesel in the transportation fuel market. Biodiesel regulatory challenges and opportunities include:

DOE Alternative Fuels Definition

Twin Rivers Technologies (TRT), a biodiesel fuel supplier, petitioned DOE to designate biodiesel blended with petroleum diesel as an alternative fuel. This will provide it with the status needed to gain the benefits provided to other alternative fuels such as natural gas and ethanol under the Energy Policy Act of 1992 (EPACT). EPACT was enacted by Congress in 1992 to help ensure national energy security by displacing petroleum products with domestic alternative fuels such as biodiesel.

Receiving an "alternative fuel" designation at blend levels as low as 20% will allow biodiesel to play a major role under EPACT. In addition, NBB and private industry have petitioned DOE to allow alternative fuel credit trading between light-duty vehicles and medium/heavy-duty vehicles.

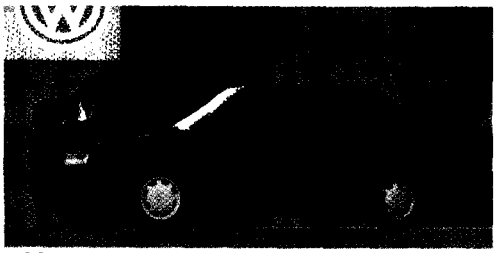
As the following table shows, biodiesel has major advantages compared to alcohol fuels in the energy content (Btu) per gallon, the efficiency achieved by engine configurations, and the amount of fossil fuel expended in the conversion process compared to energy output.

Comparison of Alternative Fuels

Fuel	Neat kBtu per gallon	Energy Balance	Engine Efficiency
Biodiesel	132.9	1 : 2.51	44%
Ethanol	75.7	1 : 1.33	35%
Methanol	56.6	1 : 0.81	35%

Source: Institute for Local Self Reliance.

NBB and ABA have also advanced the concept of classifying vehicles certified by their manufacturers to use both biodiesel and petrodiesel as flexible fuel vehicles. The Volkswagen Jetta can be bought in Europe certified to use biodiesel, and VW has stated publicly that the Jetta is a flex-fuel vehicle.



This VW Jetta is available in Europe with a diesel engine certified for both biodiesel and petrodiesel.

EPA Regulation of Off-Road Heavy-Duty Diesel Emissions

In June, 1994, EPA published regulations limiting emissions for new off-road heavy-duty engines for the first time. The new standards will apply primarily to farm equipment, forklifts, road construction vehicles, and earth-moving equipment rated at 50 horsepower or above.

EPA expects to regulate most other off-road engines in the next several years. Thus, locomotives, marine vessels, and other unregulated engines, eventually including aircraft, will face new emissions regulations. Because of the unique requirements of this large segment of the motor fuel market, and the characteristics of biodiesel, it appears that it will have a promising future in helping to meet these regulations.

EPA Urban Bus Retrofit/Rebuild Program
As technologies are certified, EPA requires urban bus fleet operators in cities with populations of more than 750,000 to decrease the amount of PM that is emitted from their 1993 and earlier model year buses.

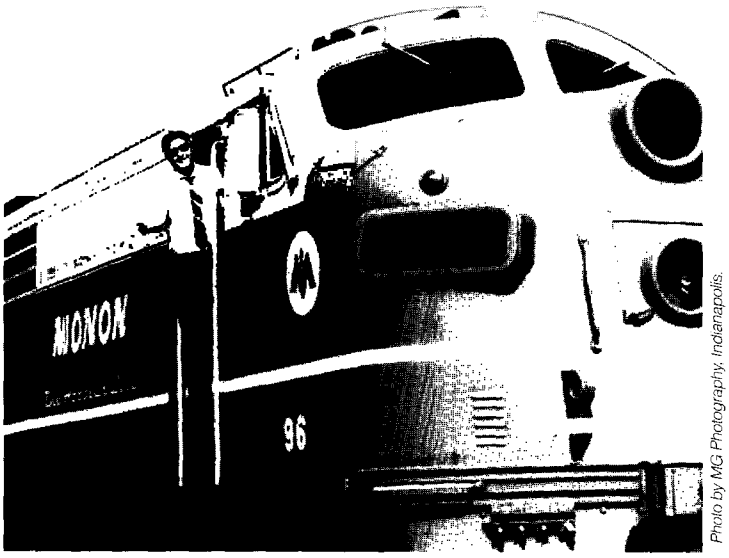


Photo by MG Photography, Indianapolis.
Courtesy of Indiana Soybean Development Council

A biodiesel-fueled train has been used to shuttle visitors to the Indiana State Fair.

For biodiesel to have access to the mass transit fleet fuel market, EPA certification of biodiesel under the Urban Bus Rebuild/Retrofit Program is important. Fuel suppliers and transit properties are submitting applications to EPA, and it is likely that they will be first in the nation to certify a modified-diesel fuel package under this program.

NBB seeks to certify different engine "families" using biodiesel and a variety of engine system modifications such as an injector timing change and an exhaust catalyst to optimize PM emissions and further reduce other regulated emissions. These packages will allow urban mass transit fleets to claim the PM reduction benefits of biodiesel.

EPA Regulations
Biodiesel is currently registered with the EPA as a fuel and a fuel additive, and can be legally introduced into commerce. EPA is in the process of evaluating several potential regulations for petroleum diesel and alternative fuels. The NBB will continue to work closely with EPA to ensure biodiesel remains in compliance with all regulatory requirements.

Benefits of Biodiesel Compared to Low-Sulfur Diesel

Fuel Characteristics	Biodiesel
Sulfur	Lower
Aromatics	Much Lower
Cetane	Higher
Lubricity	Higher
Oxygen	Higher
Performance	Equal
Emissions	Significantly lower*

*Biodiesel is part of the natural carbon cycle and, throughout the full fuel cycle, greatly reduces CO_2.

Opportunities for Biodiesel: Premium Diesel Fuel

In June, 1994, the Engine Manufacturers' Association (EMA) proposed a "premium diesel" specification to the American Society for Testing & Materials (ASTM). EMA, whose membership is comprised of North American heavy-duty engine manufacturers, told ASTM that the current diesel fuel specification is of "minimum quality and [that] it is doubtful whether that quality of fuel will be acceptable for low-emission engines."

This proposal is the first major attempt to improve diesel quality through a commercial "premium diesel" specification. The table (below) compares key fuel properties of the current diesel fuel, biodiesel, and EMA's proposed "premium diesel" specification.

This table shows that biodiesel meets or exceeds the proposed premium diesel specification being sought by the Engine Manufacturers' Association in order to meet future emissions requirements.

Selected Properties of Biodiesel

Representative Fuel Properties	Number 2 Diesel	Biodiesel	Desired "Premium" Diesel[1]
Flash Pt. °C (min.)[2]	52	118	52
Sulfur, % max.	0.05	<0.01	0.05
Cetane Number	42	50	50
Lubricity, gr., min.	2500	6000	3300

[1]June, 1994, Engine Manufacturers Association proposal.
[2]A higher flash point increases the safety of the fuel.

Market Creation

One of the most successful biodiesel market creation activities has been demonstrations in urban transit buses. These "bean buses" have been popular with the public, and have generated considerable attention for biodiesel. They have even been featured on ABC's *Good Morning, America* and mentioned by Jay Leno on NBC's *Tonight Show*.

The biodiesel industry has also had a presence at the major alternative fuels and transportation conferences. For instance, in June, 1994, NBB sponsored biodiesel-powered shuttles at the International Alternative Fuels and Clean Cities Conference in Milwaukee, WI.

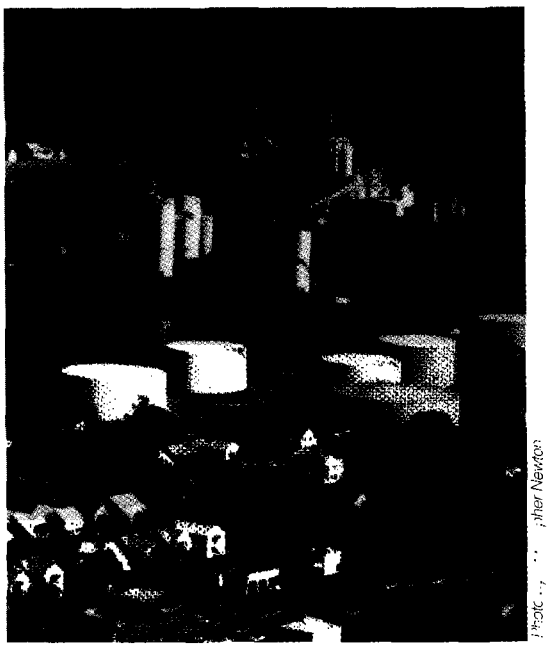
NBB representative talks with the media at Ag Day.

Some of the recent conferences in which biodiesel advocates have participated include:

- The American Public Transportation Association Conference in Richmond, VA;
- The Ag Day Celebration, the Energy Summit, the Ag Summit on New Uses, and the biodiesel briefing as part of the Congressional Soybean Caucus, all in Washington, DC;
- The Windsor Workshop on Alternative Fuels in Toronto, Canada;
- The American Society of Agricultural Engineers Fuels and Lubricants Conference in Kansas City, MO; and
- International Conference on Fuel Efficient and Clean Motor Vehicles, Mexico City.

Commercialization

One of the most positive signs for the biodiesel industry is the emergence of three private firms to distribute biodiesel to the marketplace: Interchem, Ag Environmental Products, and Twin Rivers Technologies (TRT). In addition, TRT has announced its intent to convert a soap factory in Quincy, MA, into a world-class biodiesel plant. This plant will make biodiesel from soybean oil, recycled oils, and/or animal fats.



Courtesy of Twin Rivers Technologies, Inc.

When completed, the 30 million gallon-per-year plant will be the first dedicated biodiesel plant in the United States, and one of the largest plants in the world. In the meantime, there is a supply of approximately 20 million gallons of biodiesel a year from existing U.S. producers.

Once it has been fully commercialized, biodiesel will play a major role in building a sustainable society — new bio-refineries, new jobs, and new domestic markets for farmers to enhance America's energy and economic security, to clean the air, and to help stabilize greenhouse gases.

There is a bright future for America and biodiesel is part of it.

Prepared by
American Biofuels Association
for
National Biodiesel Board
United Soybean Board
Indiana Soybean Development Council
and Qualified State Soybean Boards